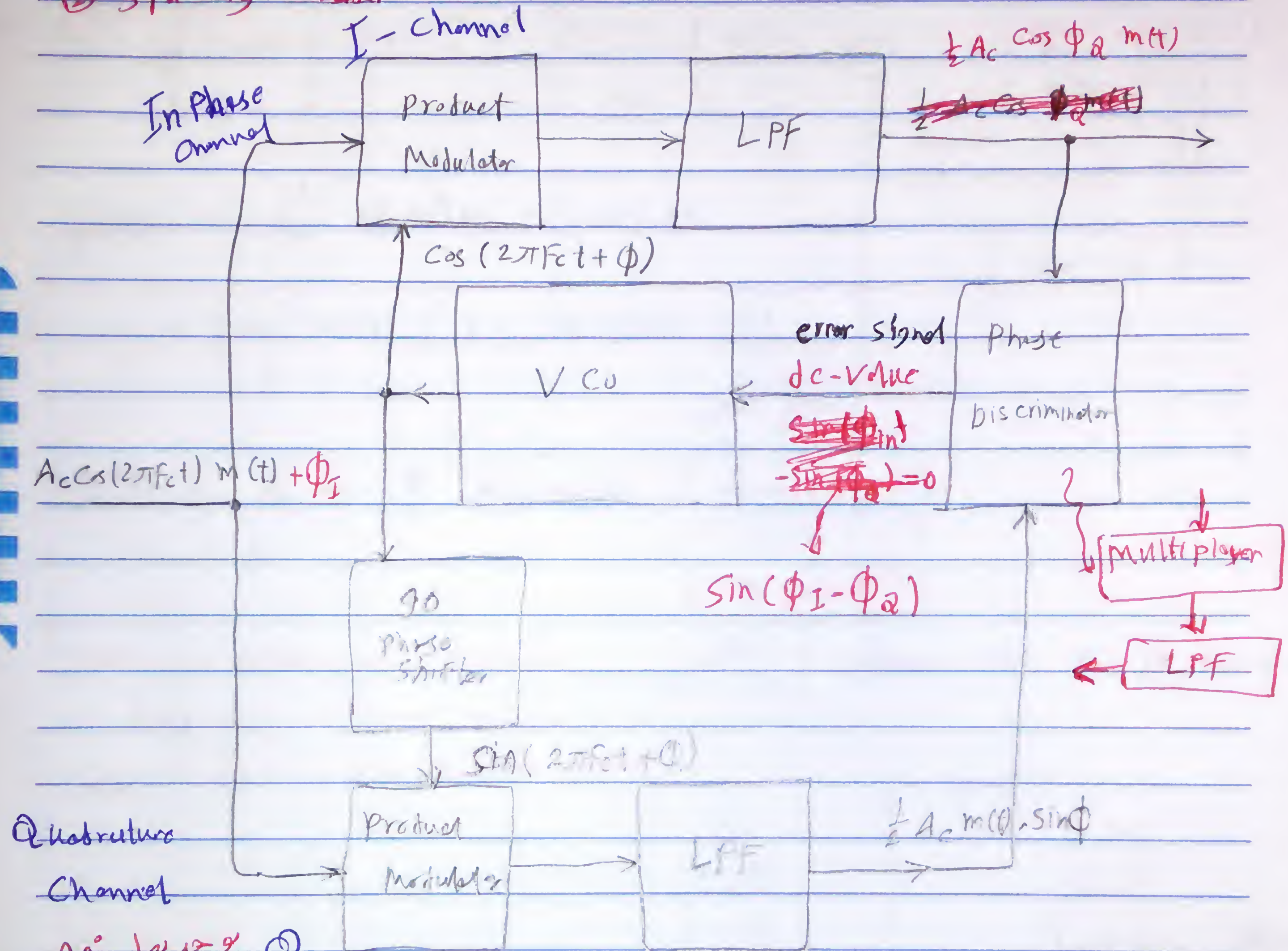
[illegible] phase-shift [illegible]

① Costas Reciver

② Squaring ~~Reciver~~ Loop

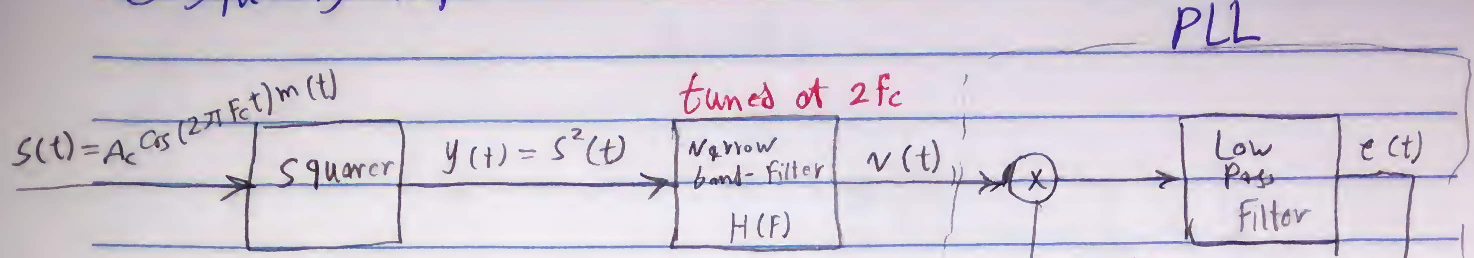


phase shift 90° [illegible] Q - Channel

VCO ⟶ Voltage Control Oscillator

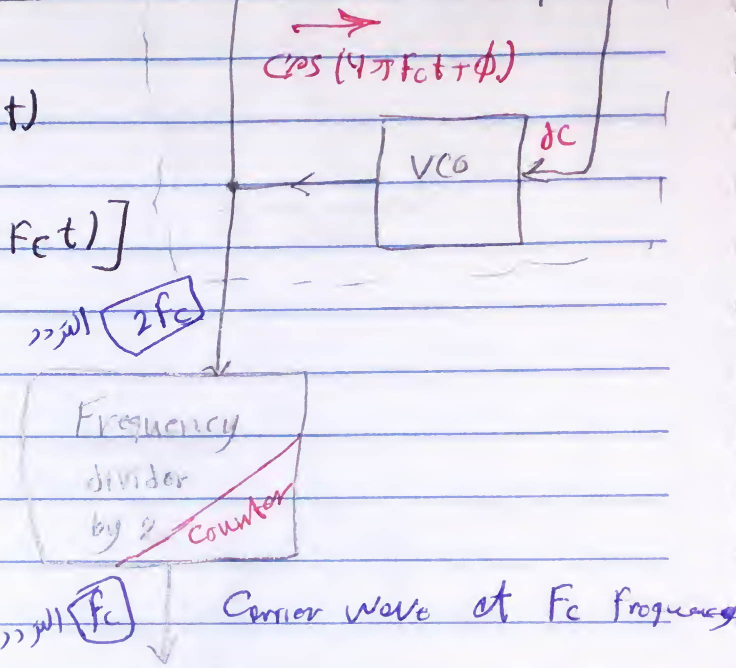
phase- tracking [illegible]

② Squaring loop



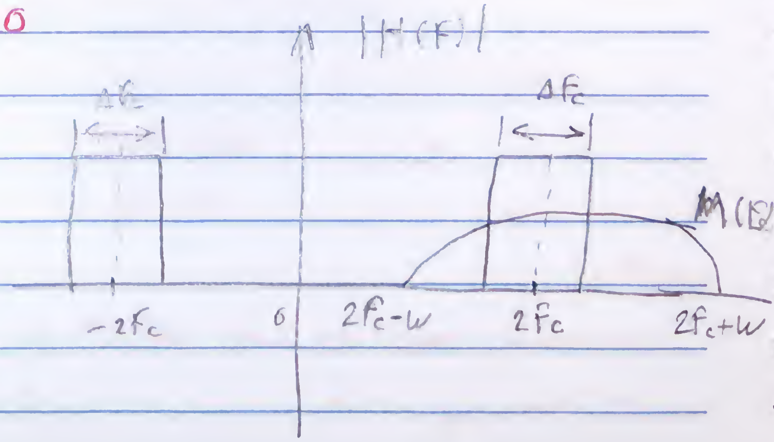
$$y(t) = A_c^2\, m^2(t)\, \cos^2(2\pi f_c t)$$

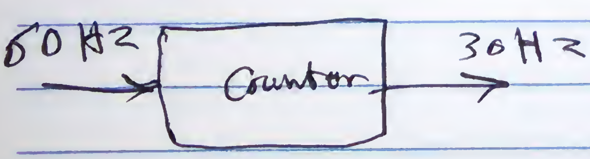
$$= \frac{1}{2}A_c^2\, m^2(t)\left[1+\cos(4\pi f_c t)\right]$$

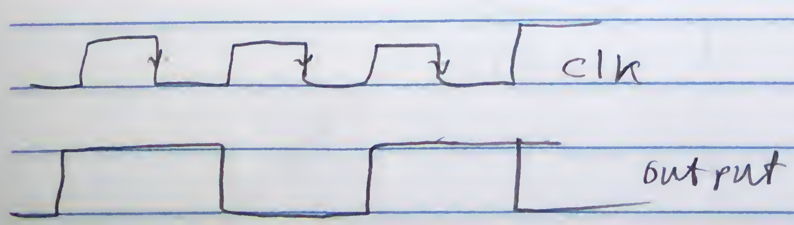


$$V(t) = A_c\, E\, \Delta F\, \cos(4\pi f_c t)$$

e(t) → difference between frequency (phase v(t)) and frequency and phase of VCO

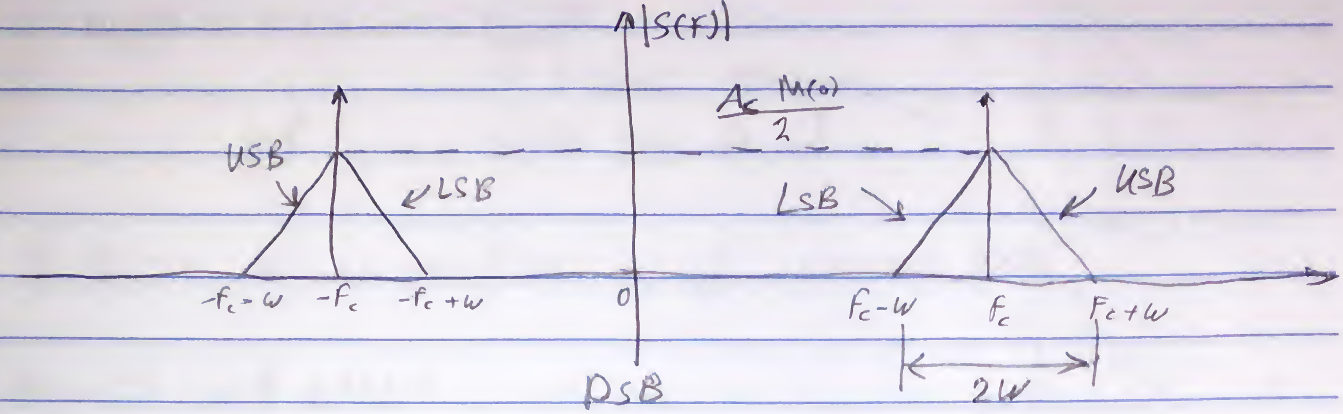


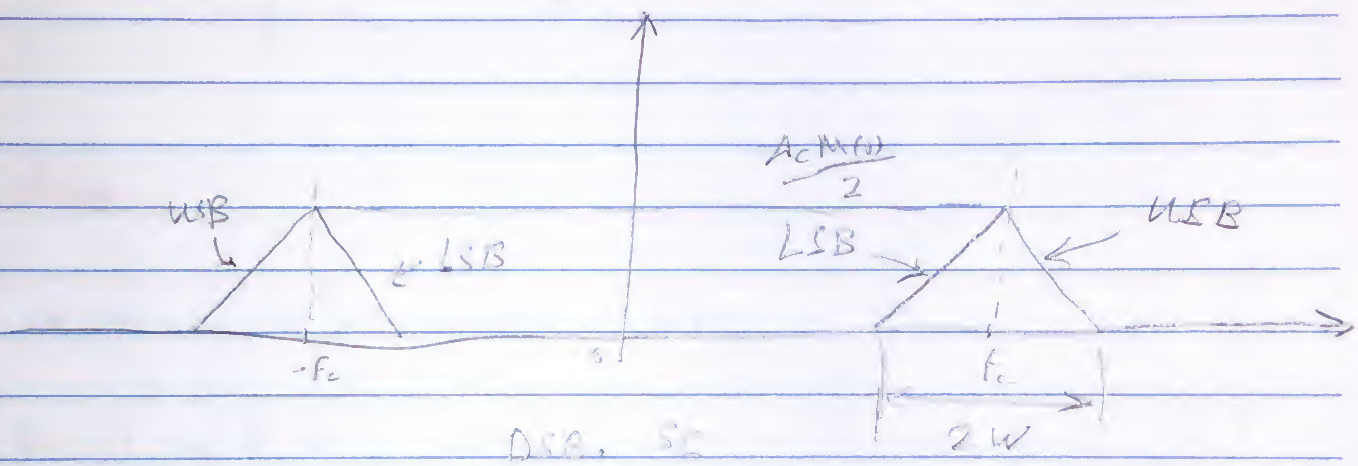




bit ※ 0

Single side band Modulation (SSB)





في حالة الـ single side band

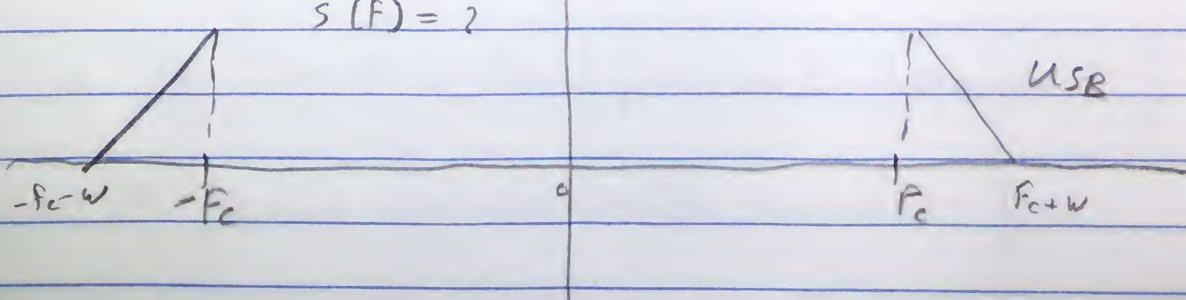
* يوفر في Band width
* يوفر في Power

مشاكلها

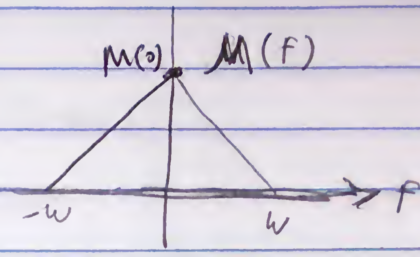
* يحتاج Perfect band pass filter
* التصميم معقد

$S(t) = ?$

$S(F) = ?$



pre-envelope of $m(t)$:

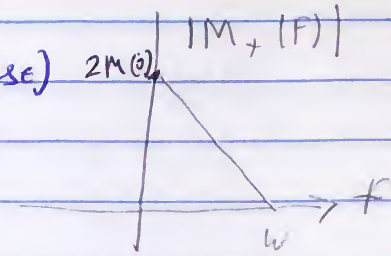


$$m_+(t) = m(t) + j\,\hat{m}(t)$$

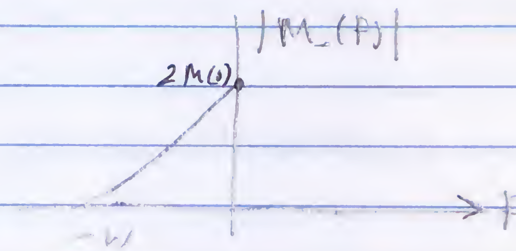
↓ Hilbert trasform

هو عمل shift بمقدار 90°

$$\hat{m}(t) = m(t) \text{ shifted by } \frac{\pi}{2} \quad (\text{Phase})$$



$$M_+(f) = \begin{cases} 2M(f) & f > 0 \\ 0 & f < 0 \end{cases}$$



$\cancel{\hat{m}(t)} =$

$$m_-(t) = m_+^*(t) = m(t) - j\,\hat{m}(t)$$

$$M_-(f) = \begin{cases} 0 & f > 0 \\ 2M(f) & f < 0 \end{cases}$$

$$\hat{M}(f) = M(f)\cdot e^{j\frac{\pi}{2}}$$

To get single side band : Upper Side Band

$$s(t) = \left[m_+(t)\, e^{j2\pi f_c t} + m_-(t)\, e^{-j2\pi f_c} \right] \frac{A_c}{4}$$

$$s(t) = \frac{A_c}{4}\left[\left(m(t) + j\,\hat{m}(t)\right)\left(\cos(2\pi f_c t) + j \sin(2\pi f_c t)\right)\right]$$

$$+ \frac{A_c}{4}\left[\left(m(t) - j\,\hat{m}(t)\right)\left(\cos(2\pi f_c t) - j \sin(2\pi f_c t)\right)\right]$$

$$= \frac{A_c}{4}\left[2\,m(t) \cos(2\pi f_c t) - 2\,\hat{m}(t) \sin(2\pi f_c t)\right]$$

$$= \frac{A_c}{2}\left[m(t) \cos(2\pi f_c t) - \hat{m}(t) \sin(2\pi f_c t)\right] \quad \#$$

Lower Side Band

$$s(t) = \frac{A_c}{2}\left[m(t) \cos(2\pi f_c t) + \hat{m}(t) \sin(2\pi f_c t) \right]$$

For single side band

$$s(t) = \frac{A_c}{2}\left[m(t) \cos(2\pi f_c t) \mp \hat{m}(t) \sin(2\pi f_c t) \right]$$

Ex: $m(t) = A_m \cos(2\pi f_m t)$

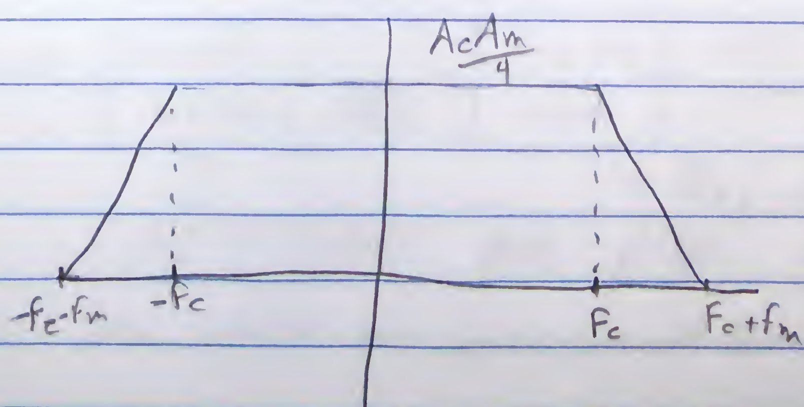
Find USB A_m

$$\hat{m}(t) = A_m \cos\left(2\pi f_m t + \frac{\pi}{2}\right) = A_m \sin(2\pi f_m t)$$

$$s(t) = \frac{A_c}{2}\left[A_m \cos(2\pi f_m t) \cos(2\pi f_c t) - A_m \sin(2\pi f_m t) \sin(2\pi f_c t) \right]$$

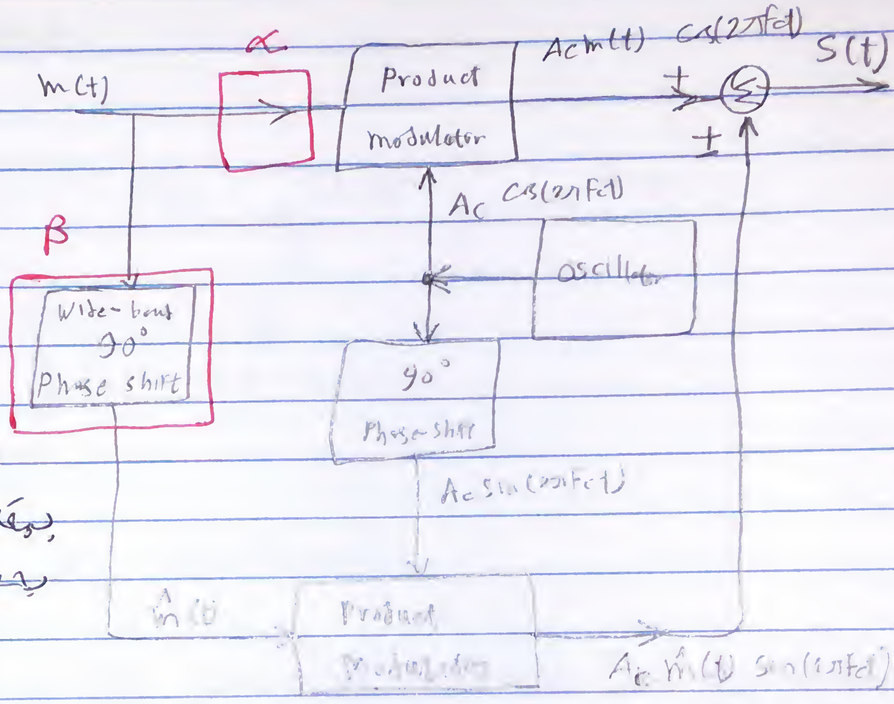
$$= \frac{A_c A_m}{2} \cos(2\pi (f_m + f_c) t)$$

$$S(f) = \frac{A_c A_m}{4}\left[\delta(f + f_c + f_m) + \delta(f - f_c - f_m) \right]$$



Generation of SSB Waves :

1. phase discriminator
2. Frequency discriminator



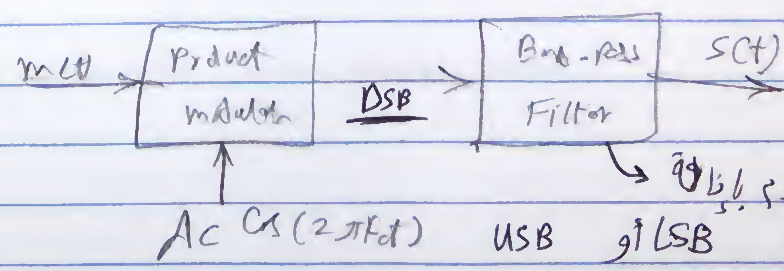
بعض الأوقات
تعدل الدائرة
بدائرتين لل Shift
بمقدار α , β
بحيث

$$\alpha - \beta = \frac{\pi}{2}$$

هذا يعطي مدى أعلى من
استقبال ترددات m(t)
ولا يحدث أي إهمال لجزء من m(t)

Phase discriminator

Frequen discriminator



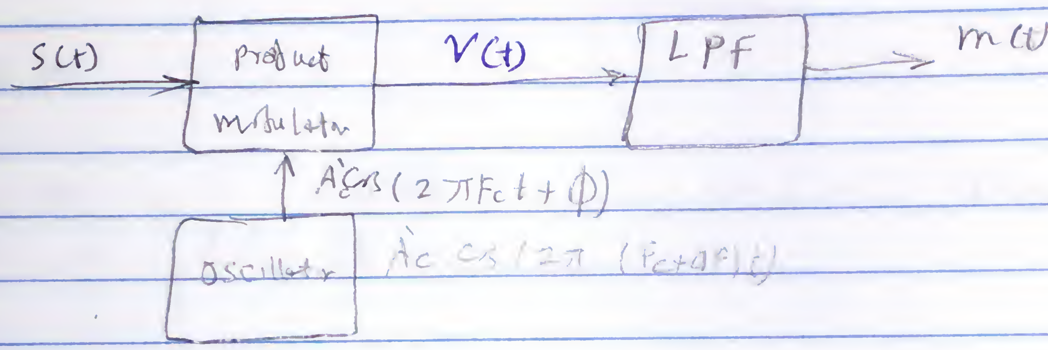
يقوم بإزالة
إما LSB أو USB

من الصعب تنفيذ هذه الدائرة عملياً

De modulation of SSB :

$$S(t) = \frac{A_c}{2}[\, m(t) \cdot \cos(2\pi f_c t) \mp \hat{m}(t) \sin(2\pi f_c t)]$$

Coherent Detector



$$V(t) = S(t) \cdot A_c' \cos(2\pi f_c t)$$

$$= \frac{A_c A_c'}{2}[\, m(t) \underbrace{\cos(2\pi f_c t) \cos(2\pi f_c t)}_{\cos^2(2\pi f_c t)} \mp \underbrace{\hat{m}(t) \sin(2\pi f_c t)\cos(2\pi f_c t)}_{\frac{1}{2}\hat{m}(t) \sin(4\pi f_c t)}]$$

$$= \frac{A_c A_c'}{2}\left[\frac{1}{2} m(t) [1 - \cos(4\pi f_c t)]\right]$$

$$= \frac{A_c A_c'}{4} m(t) \quad \cos\phi \longrightarrow \text{Phase error}$$

Date :

Angle Modulation

$S(t) = A_c \cos(\theta_i(t))$

AM wave

$$S(t) = A_c [1 + K_a m(t)] \cos(2\pi F_c t + \phi)$$

$\phi = 0$

$\theta_i(t)$

$f_i(t) = \frac{1}{2\pi} \frac{d\theta_i(t)}{dt}$ = instantinous Frequency

FM wave → F_c PM wave → ϕ

$S(t) = A_c \cos(2\pi F_c t + \phi_c)$

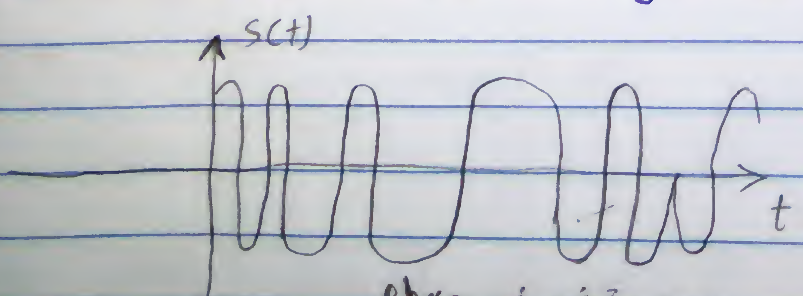
un modulated Frequency → un modulated Angle

$\theta_i(t) = 2\pi F_c t + \phi_c$

PM wave → $\theta_i(t) = 2\pi F_c t + K_p m(t)$

K_p → phase Sensitivty

$$S(t) = A_c \cos[2\pi F_c t + K_p m(t)]$$



يوجد تغير في phase

$$f_i(t) = \frac{1}{2\pi} \frac{d\theta_i(t)}{dt}$$

$$\theta_i(t) = 2\pi \int_0^t f_i(t)\, dt$$

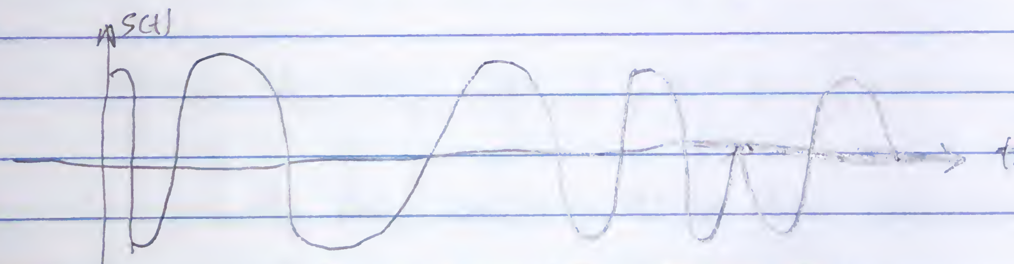
FM $\rightarrow$ $f_i(t) = f_c + K_f \cdot m(t)$

$K_f \rightarrow$ frequency Sensitivity

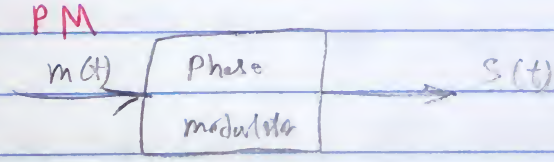
$$\theta_i(t) = 2\pi \int_0^t [f_c + K_f\, m(t)]\, dt$$

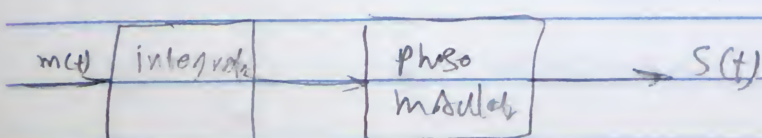
$$\theta_i(t) = 2\pi f_c t + 2\pi K_f \int_0^t m(t)\, dt$$

$$S(t) = A_c \cos\left[2\pi f_c t + 2\pi K_f \int_0^t m(t)\, dt\right]$$

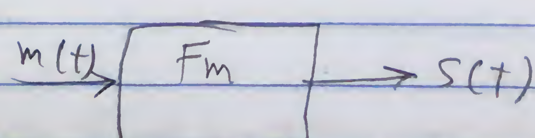


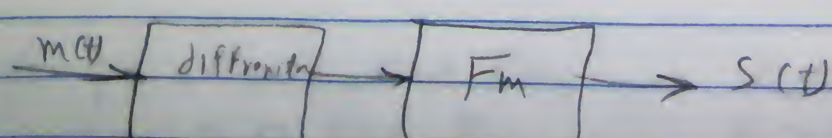
FM from PM





PM from FM





FM and PM $\longrightarrow$ better than $\longrightarrow$ AM

بسبب أنها لا تتأثر بشدة بـ noise

لأنه Amplitude ثابتة

وعيبه هو تعقيد الدائرة والتكلفة العالية

FM Type:

1. single tone Fm
2. multi tone Fm

* Single tone:

$$m(t) = A_m \cos(2\pi F_m t)$$

$$S(t) = A_c \cos\left[2\pi f_c t + 2\pi K_f \int_0^t m(t)\,dt\right]$$

$$= A_c \cos\left[2\pi f_c t + 2\pi K_f \frac{A_m}{2\pi f_m} \sin(2\pi f_m t)\right]$$

$\Delta F = \pm K_f A_m$ Frequency ~~[illegible]~~ deviation

$$S(t) = A_c \cos\left(2\pi f_c t + \frac{\Delta f}{f_m} \sin(2\pi f_m t)\right]$$

$\beta = \dfrac{\Delta f}{F_m} \longrightarrow$ modulation index

$$\text{Freq}_{\max} = F_c \pm K_f A_m = F_c \pm \Delta f$$

$$S(t) = A_c \cos\left[2\pi f_c t + \beta \sin(2\pi f_m t)\right]$$

$\beta \rightarrow$ Narrow Band Fm $\quad \beta < 1$

$\beta \rightarrow$ Wide Band Fm $\quad \beta > 1$

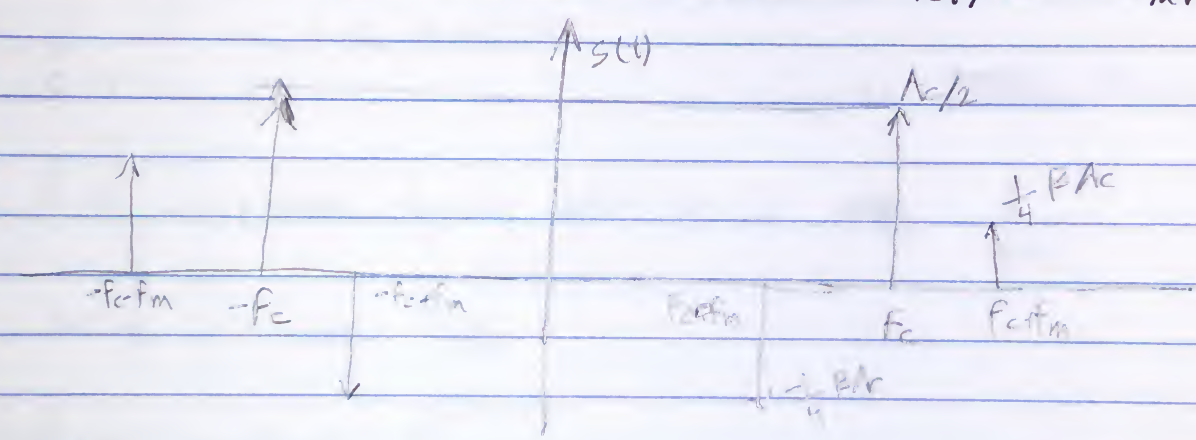
Narrow Band FM wave

β is very small

$$S(t) = A_c \cos(2\pi f_c t) \underbrace{\cos[\beta \sin(2\pi f_m t)]}_{\simeq 1}$$

$$- A_c \sin(2\pi f_c t) \underbrace{\sin[\beta \sin(2\pi f_m t)]}_{\simeq \beta \sin(2\pi f_m t)}$$

$$S(t) = A_c \cos(2\pi f_c t) - A_c \beta \sin(2\pi f_c t) \sin(2\pi f_m t)$$



$$S(t) = A_c \cos(2\pi f_c t) + \frac{1}{2} \beta A_c \left[\cos(2\pi(f_c+f_m)t) - \cos(2\pi(f_c-f_m)t)\right]$$

B.W = 2fm

* Wide Band frequency Modulator

$\beta >> 1$

$S(t) = A_c \cos[2\pi f_c t + \beta \sin(2\pi f_m t)]$

$= A_c \text{ Real}\{ e^{j2\pi f_c t + \beta \sin(2\pi f_m t)} \}$

$= A_c \text{ Real}\{ e^{j2\pi f_c t} \cdot e^{j\beta \sin(2\pi f_m t)} \}$

$\hat{S}(t) = e^{j\beta \sin(2\pi f_m t)} \longrightarrow$ Complex ~~Envelope~~ Envelope

$\hat{S}(t) \longrightarrow$ periodic signal with period $\frac{1}{f_m}$

Using Complex F.S.

$\hat{S}(t) = \sum C_n e^{j2\pi n f_m t}$

$C_n = f_m \int_{-\frac{1}{2f_m}}^{\frac{1}{2f_m}} \hat{S}(t) \cdot e^{-j2\pi f_m t} \, dt$

$= f_m \int_{-\frac{1}{2f_m}}^{\frac{1}{2f_m}} e^{j\beta \sin(2\pi f_m)} \cdot e^{-j2\pi f_m t} \, dt$

$= f_m \int_{-\frac{1}{2f_m}}^{\frac{1}{2f_m}} e^{j[\beta \sin(2\pi f_m t) - 2\pi f_m t]} \, dt$

$X = 2\pi f_m t$

$dX = 2\pi f_m \, dt$

$$C_n = \cancel{f_m} \int_{-\pi}^{\pi} \frac{1}{2\pi \cancel{f_m}} e^{j[\beta \sin(x) - nx]} \, dx$$

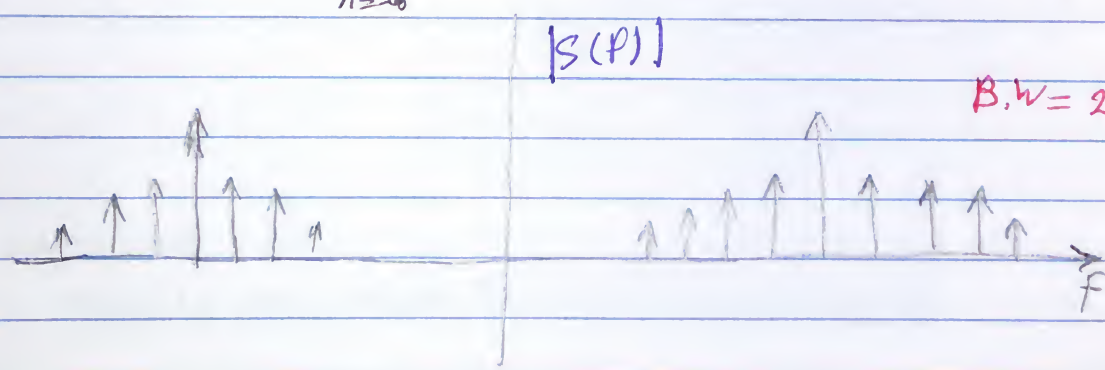
$$J_n(\beta) = \frac{1}{2\pi} \int_{-\pi}^{\pi} e^{j[\beta \sin(x) - nx]} \, dx \quad \text{Bessel Function}$$

$$C_n = J_n(\beta)$$

$$\hat{s}(t) = \sum_{n=\infty}^{\infty} J_n(\beta) \, e^{j 2\pi f_m t}$$

$$s(t) = A_c \, \text{Real} \left\{ e^{j2\pi f_c t} \sum_{n=-\infty}^{\infty} J_n(\beta) \, e^{j2\pi f_m t} \right\}$$

$$= A_c \sum_{n=-\infty}^{\infty} J_n(\beta) \cos(2\pi (f_c + n f_m) t)$$



$B.W = 2\Delta f + 2F_m$

$J_n(\beta)$ properties

$n = 0 \qquad J_0(\beta) = 1$

$n = \text{even} \qquad J_n(\beta) = J_{-n}(\beta)$

$n = \text{odd} \qquad J_n(\beta) = -(1) J_{-n}(\beta)$

$$J_n(\beta) = (-1)^n J_{-n}(\beta)$$

$$\boxed{\sum_{-\infty}^{\infty} J_n^2(\beta) = 1}$$

* Generation of FM waves:

Transmission band width of FM wave:

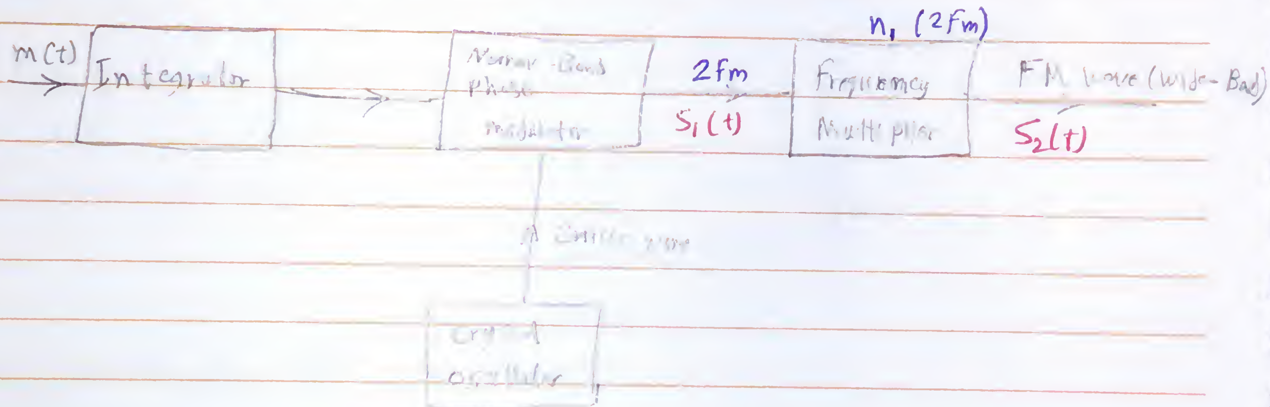
Carson's rule (wide Band FM)

$B.W. \simeq 2\Delta F + 2f_m \simeq 2 n_{max} f_m$

$|J_n(\beta)| > 0.01$

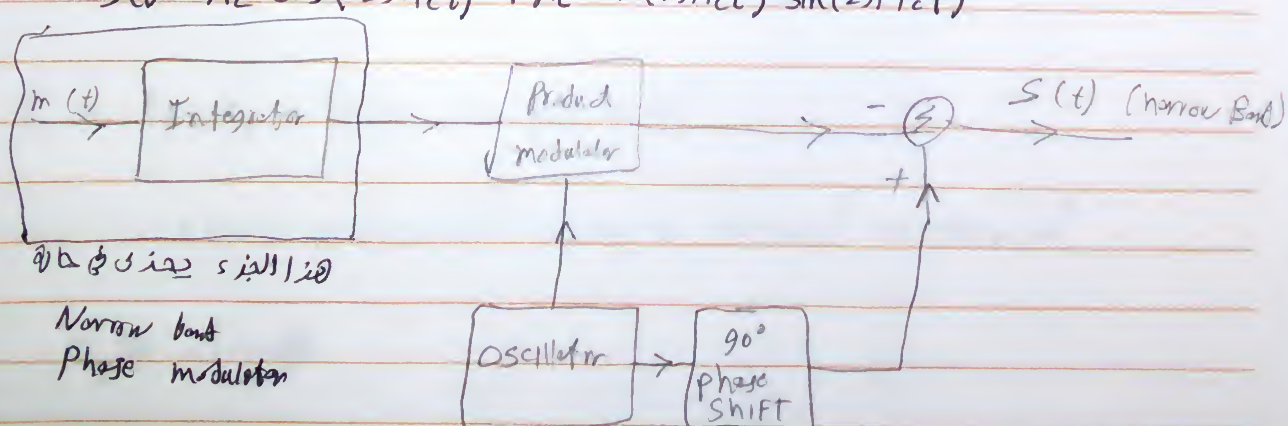
$\Delta F = \frac{K_f A_m}{f_m}$ ~~$\simeq 2 n_{max} f_m$~~

* Indirect ~~method~~ FM generator:



narrow Band (FM)

$S(t) = A_c \cos(2\pi f_c t) - \beta A_c \sin(2\pi f_c t) \sin(2\pi F_c t)$

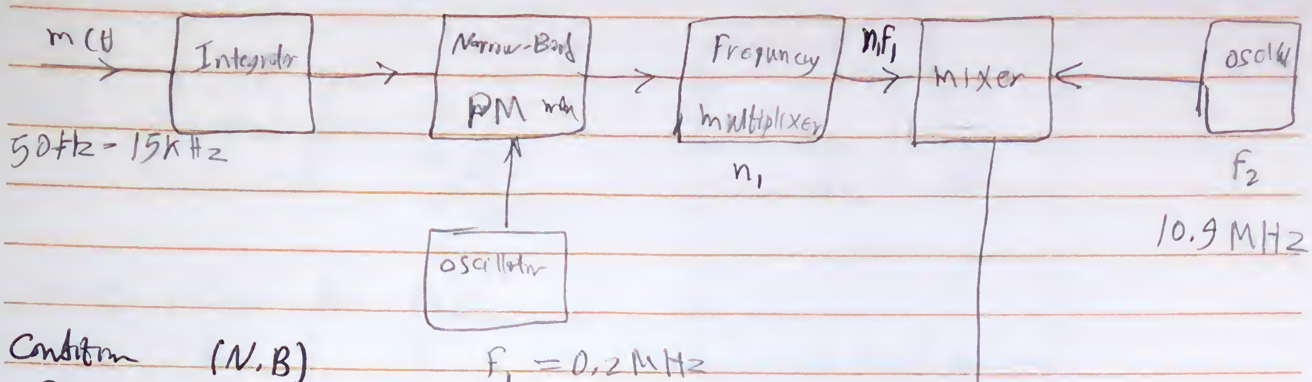


$S_1(t) = A_1 \cos[2\pi f_c t + 2\pi K_f \int_0^t m(t)\, dt]$ if $m(t) = A_m \cos(2\pi f_m t)$

$S_1(t) = A_1 \cos[2\pi f_c t + \beta_1 \sin(2\pi f_m t)]$ $\beta_1 \ll 1$

$S_2(t) = A_1 \cos[2\pi f_c t + n_1 \beta_1 \sin(2\pi f_m t)]$ $n_1 \beta_1 \gg 1$

Example : Find n_1 , n_2



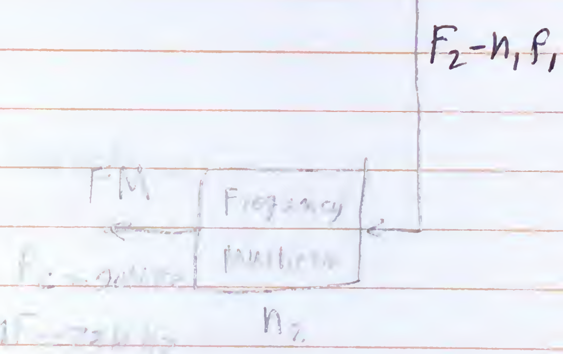
Condition (N.B)

$\beta < 1$

$B_{max} = 0.5$

$\Delta F_1 = \beta_1 \cdot f_m$

$\Delta F_1 = 0.5 * 50\ Hz = 25\ Hz$



$\Delta F_{final} = n_1 \cdot n_2 \cdot \Delta F_1 = 75\ kHz$

$$\boxed{n_1 \cdot n_2 = 3000}$$

$f_c = -n_1 n_2 F_1 + n_2 F_2 = 90 * 10^6$

$-3000 * 0.2 * 10^6 + n_2 * 10.9 * 10^6 = 90 * 10^6$

$n_2 \simeq 63$

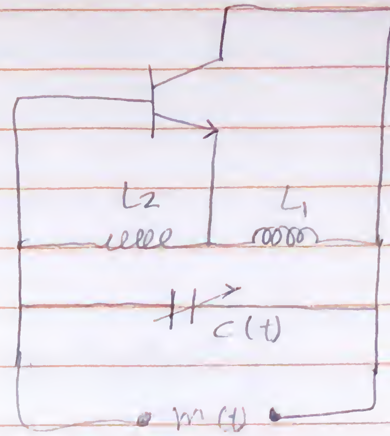
$n_1 \simeq 48$

* Direct methods Direct FM generator

* Voltage Controlled oscillator

$m(t) \longrightarrow \boxed{VCO} \longrightarrow s(t)$

Variable of Frequency



Hartly oscillator VCO

$$C(t) = C_o + \Delta C \, m(t)$$

C_o ↓ Capactance in the absence of modulation

$m(t)$ ↓ base band signal

$\Delta C \longrightarrow$ max Change of Capactance

يتم الحصول على هذا المكثف من خلال

- P.n Junction with reverse biase
- diode → Varactor , or Vari Cap

$$f_i = \frac{1}{2\pi\sqrt{(L_1+L_2)\,C(t)}} = \frac{1}{2\pi\sqrt{(L_1+L_2)\left[C_o + \Delta C \, m(t)\right]}}$$

if $m(t) = \cos(2\pi f_m t)$

$$f_i(t) = f_o\left[1 + \frac{\Delta C}{C_o}\cos(2\pi f_m t)\right]^{-1/2}$$

$$f_o = \frac{1}{2\pi\sqrt{(L_1+L_2)\,C_o}}$$

Page :
Date :

$$F_1(t) \simeq F_0\left[1+\frac{\Delta C}{C_0}\cos(2\pi f_m t)+\cdots\right]$$

$$\boxed{\Delta C < C_0}$$

$$\frac{-\Delta C}{2C_0}=\frac{\Delta F}{F_m}$$

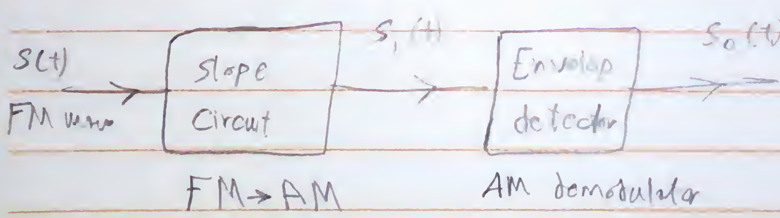
$$\therefore F_1(t)=F_0\left[1+\frac{\Delta F}{f_m}\cos(2\pi f_m t)\right]$$

Instantinous frequency of FM wave

dis advantage $\longrightarrow$ * Un stable Frequency
* Varible capacitance is not Linear

* Detection of FM wave:
1. Slope detector
2. PLL $\rightarrow$ Phase Locked - Loop

[1] Slope detector



Slope Circuit $\longrightarrow$ diffrenciator

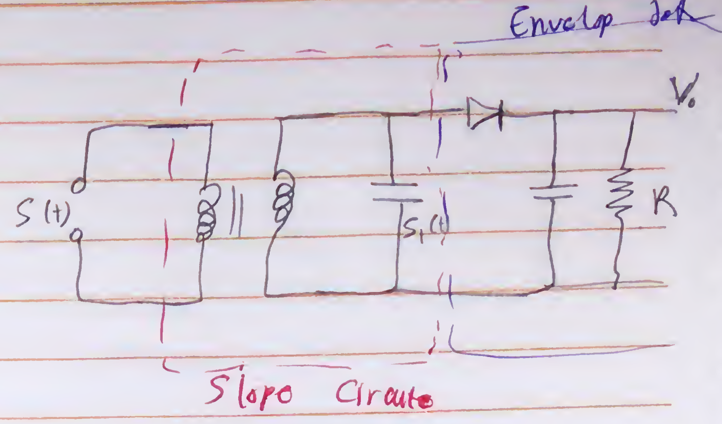
$$S(t)=A_c\cos\left[2\pi f_c t+2\pi K_f\int_0^t m(t)\,dt\right]$$

$$S_1(t)=-A_c\left[2\pi f_c+2\pi K_f\, m(t)\right]\sin\left[2\pi f_c t+2\pi K_f\int_0^t m(t)\,dt\right]$$

$$S_0(t)=-A_c\left[2\pi f_c+2\pi K_f\, m(t)\right]$$

$$S_0(t)\propto m(t)$$

Slope Circuite



② phase - Looked - Loop :